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PORTABLE PROBE TYPE IONIZATION METER, MARK II, MODEL 10

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By G. R. Carlson

A request was made by Mr. J. E. Rose of the Health Physics section at the Metallurgical Laboratory for a probe type portable radiation meter that could be used for the localization of small sources and beams of gamma and beta radiation. One such application would be the localization of the gamma and beta activity in a chemical separation or preparation carried out in a glass vacuum system. To be able thus to measure radiation intensity at essentially a point, it was decided to use a small chamber of 25 cc volume with full scale sensitivities ranging by factors of ten, from 0.2 r/hr on the most sensitive scale to 200 r/hr on the least sensitive scale.

The complete instrument consists then of a probe connected to a battery box by means of a cable. The probe consists of the ion chamber and the circuit box so that range switching is done at the probe. The battery box contains the batteries, the meter, and the circuit components other than the input tube. The on-off switch, zero set, calibration adjustment, and the feedback controls are on the battery box. The voltage sensitivity of the most sensitive circuit available to be adapted for this use is about 1/4 volt full scale, so that in order to make sensitivity as high as 0.2 r/hr it was necessary to use an input resistor of 10^{12} ohms for the most sensitive scale.

A circuit box was built to contain the input tube (Victoreen V-32), a molded polystyrene switch (used in "Zeus", CP-2452), and the high resistors. The high resistors were connected in series to the grid of the tube, and the switch connected the chamber to the various junctions between resistors. A feedback voltage was applied to the chamber in order to speed up the circuit (see "Zeuto", CP-3168).

This system worked well for betas, but there was a large amount of ion collection in the circuit box in a gamma radiation field.

It was immediately noted that the major source of spurious ion current was due to an ion collection because of the difference in potential between the grid and the circuit box. The feedback voltage was then connected to the circuit box in addition to the chamber, and the d-c voltage of the circuit box was made adjustable. This made it possible to maintain zero voltage between the grid and the circuit box.

The above emphasized a second source of undesired current. There is a large voltage drop across the largest of the input resistors (i.e., 1/4 to 1 volt due to grid current) when a V-32 tube is used as the input tube. In a strong radiation field this gave rise to a considerable current. This collection took place primarily between the switch arm and the grid.

The effect can be made negligible by switching in the input resistors independently instead of having them in series. This means though that the bias on the input tube has to be

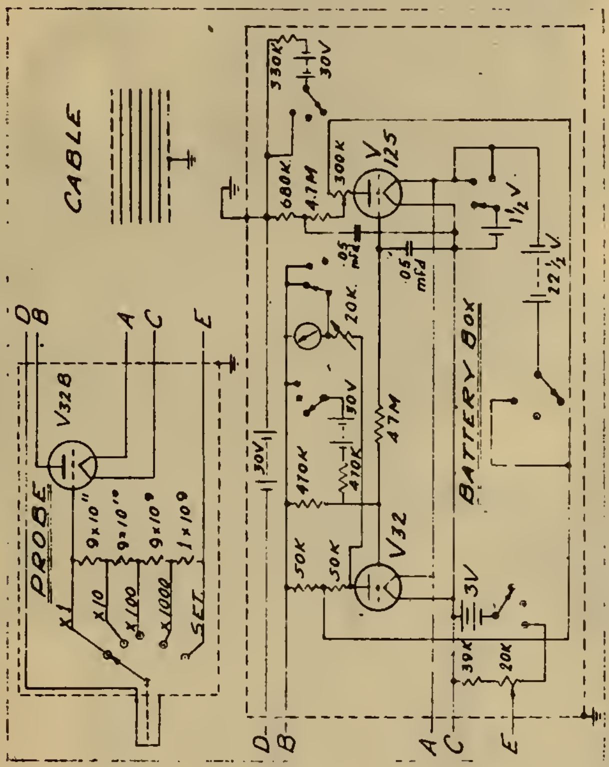
switched at the same time that the sensitivity is changed. This, of course, complicates the switching and the zero calibration. One such circuit was built and tested but it was found to be inconvenient.

To avoid this complication, the circuit was redesigned to use the electrometer tube (VE-124) which has a negligible grid current. The voltage across a 10^{12} resistor resulting from grid current is less than 1 per cent of that corresponding to full scale, so that any collection across the resistor would change the bias by a negligible amount. The resistors were no longer connected in series. This made the circuit faster on the less sensitive scales. This circuit also made the adjustments of feedback and sensitivity independent.

It was decided finally that the more popular Zeuto circuit with the series high resistors should be used. With this circuit the circuit box voltage control does not eliminate spurious ion current collection, so the switch and circuit box were radically redesigned by Dr. F. R. Shonka. The present switch has a negligible air volume for ion production (about 0.1 c.c.) and the resistors and tube are embedded in ceresin wax, so that there is no longer any concern about ion collection between elements within the circuit box because of voltage differences. Therefore, it is no longer necessary to adjust the d-c voltage of the circuit box. The feedback to the circuit box was retained to compensate for the increased dielectric constant of the wax.

The Zeuto circuit requires that the switch be made a non-shorting type, because a shorting type switch short circuits the voltage across the high resistors during the switching operation. This throws into the circuit a pulse which takes a long time to decay. The switching action is quite smooth except when going from the 2 r/hr scale to the 0.2 r/hr scale when a pulse is introduced which takes a few seconds to decay (10 to 30). This may be attributable to the change in voltage occurring across the chamber which must decay through the 10^{12} resistor. Going in the other direction, the pulse is negligible, possibly because the voltage change can decay across the 10^{12} ohm resistor.

Procedure for calibration of instrument is as follows: with the feedback control set at minimum (counter-clockwise in the production model), the probe is placed in a uniform known radiation field. The probe switch is rotated to the set position and the instrument is set to zero by means of the zero-set control on the front of the battery box. It must be kept in mind that the circuit is very sluggish with the feedback control at minimum. The instrument should remain at zero for at least ten minutes before it can be assumed that the zero is set properly. The probe switch may then be rotated to the appropriate scale until the meter reads properly. This is also a "slow" adjustment. After this adjustment is properly made, the circuit may be speeded up by adjustment of the feedback control. It is necessary to go through this procedure every time the instrument is calibrated, because the sensitivity control affects the feedback adjustment.



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INSTRUMENT SECTION
METALLURGICAL LABORATORY UNIVERSITY OF CHICAGO

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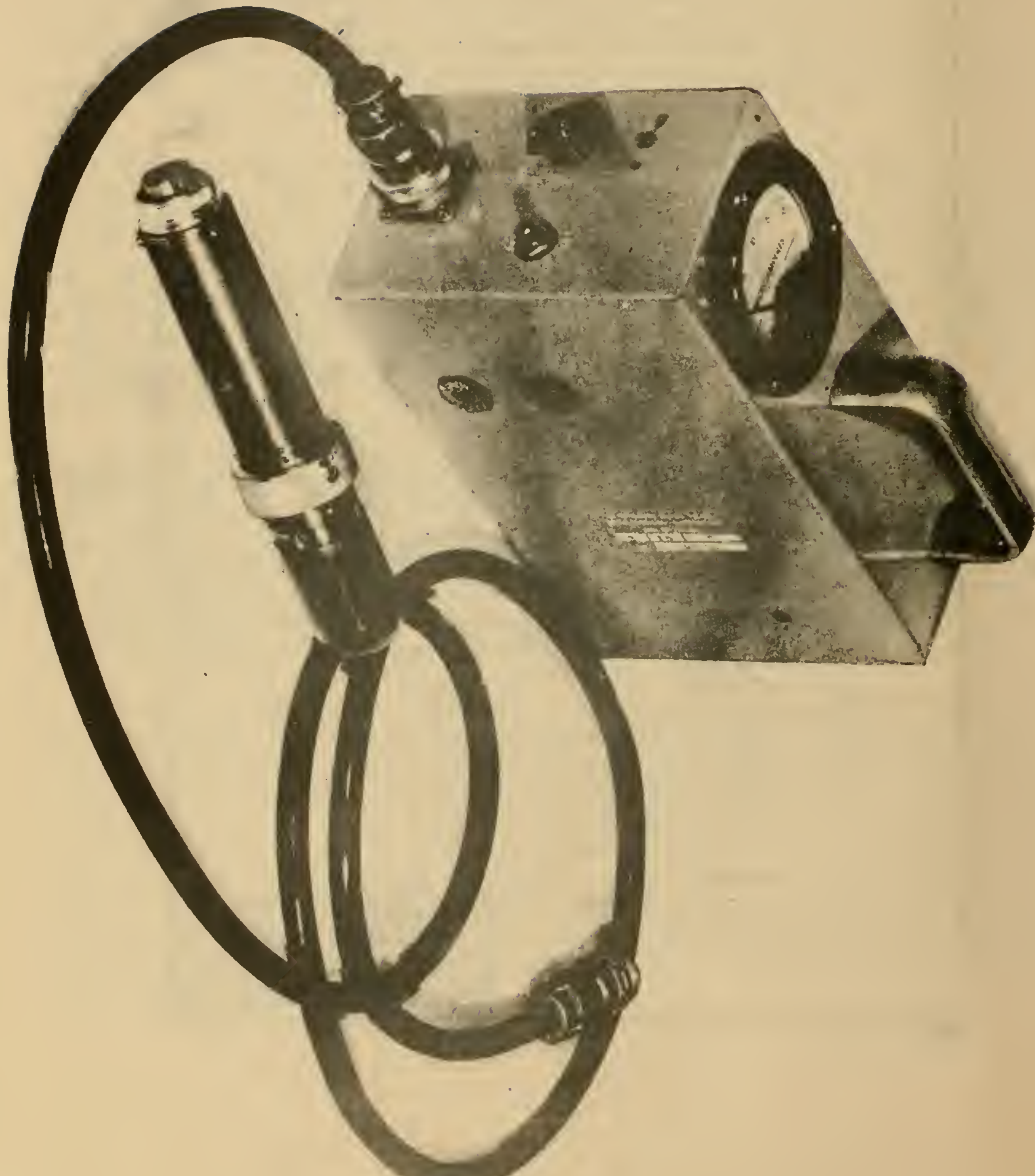

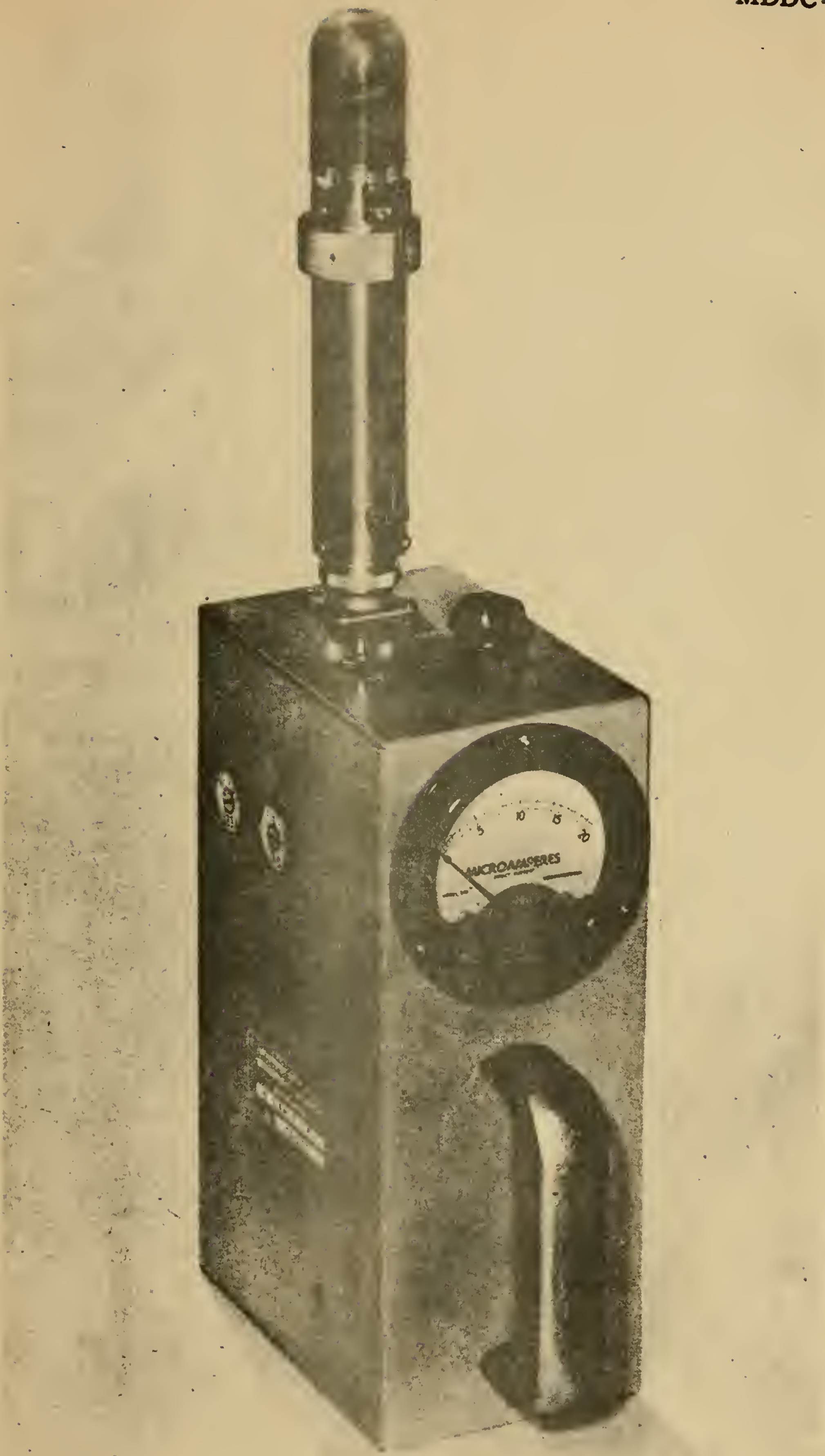
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